OCCLUSAL BITE FORCE CHANGES DURING FIXED ORTHODONTIC TREATMENT IN DIFFERENT VERTICAL FACIAL MORPHOLOGY

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2014-2017

CERTIFICATE

This is to certify that Dr. A. PREMA, Post graduate student (2014-2017) in the department of Orthodontics and Dentofacial Orthopaedics, Tamil Nadu Govt. Dental College and Hospital, Chennai- 600 003, has done this dissertation entitled "OCCLUSAL BITE FORCE CHANGES DURING FIXED ORTHODONTIC TREATMENT IN DIFFERENT VERTICAL FACIAL MORPHOLOGY" under my direct guidance and supervision for the partial fulfilment of M.D.S. Orthodontics and Dentofacial Orthopaedics (Branch V) degree examination (April, 2017) as per regulation laid down by Tamil Nadu Dr. M.G.R. Medical University Chennai-600 032 .

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DECLARATION

I, **DR. A. PREMA**, do hereby declare that the dissertation titled **"**OCCLUSAL BITE FORCE CHANGES DURING FIXED ORTHODONTIC TREATMENT IN DIFFERENT VERTICAL FACIAL MORPHOLOGY**"** was done in the Department of Orthodontics and Dentofacial Orthopaedics, Tamil Nadu Government Dental College & Hospital, Chennai 600 003. I have utilized the facilities provided in the Government Dental College for the study in partial fulfilment of the requirements for the degree of Master of Dental Surgery in the speciality of Orthodontics and Dentofacial Orthopaedics (Branch V) during the course period 2014-2017 under the conceptualization and guidance of my dissertation guide, **PROFESSOR & H.O.D., DR. G. VIMALA, M.D.S**.

I declare that no part of the dissertation will be utilized for gaining financial assistance for research or other promotions without obtaining prior permission from the Tamil Nadu Government Dental College & Hospital.

I also declare that no part of this work will be published either in the print or electronic media except with those who have been actively involved in this dissertation work and I firmly affirm that the right to preserve or publish this work rests solely with the prior permission of the Principal, Tamil Nadu Government Dental College & Hospital, Chennai 600 003, but with the vested right that I shall be cited as the author(s).

Signature of the PG student

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I seek the blessings of the Almighty God without whose benevolence; the study would not have been possible.

TRIPARTITE AGREEMENT

This agreement herein after the “agreement”I entered into on this ---day of December 2016 between the Tamil Nadu Government Dental College and Hospital represented by its **Principal** having address at Tamil nadu Government Dental College and Hospital, Chennai-03, (hereafter referred to as, “the college”)

And

Dr. G. Vimala aged 48 years working as Head & Professor at the college, having residence at AP 115, 5th Street, AF Block, 11th main road, Anna Nagar, Chennai 600040, Tamil Nadu (Herein after referred to as the ‘Principal investigator’)

And

Dr. A. Prema aged 31 years currently studying as postgraduate student in Department of Orthodontics in Tamil Nadu Government Dental College and Hospital (Herein after referred to as the “PG/Research student and co-investigator”)

Whereas the, PG/Research student as part of his curriculum undertakes to research “*O**cclusal bite force changes during fixed orthodontuic treatment in different vertical facial morphology***” for which purpose the PG/Principal investigator shall act as Principal investigator and the college shall provide the requisite infrastructure based on availability and also provide facility to the PG/Research student as to the extent possible as a Co-investigator.

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8. The Principal Investigator shall suitably guide the Student Research right from selection of the Research Topic and Area till its completion. However the selection and conduct of research, topic and area of research by the student researcher under guidance from the Principal Investigator shall be subject to the prior approval, recommendations and comments of the Ethical Committee of the College constituted for this purpose.
9. It is agreed that as regards other aspects not covered under this agreement, but which pertain to the research undertaken by the PG student, under guidance from the Principal Investigator, the decision of the college shall be binding and final.
10. If any dispute arises as to the matters related or connected to this agreement herein, it shall be referred to arbitration in accordance with the provisions of the Arbitration and Conciliation Act, 1996.
11. In witness whereof the parties hereinabove mentioned have on this the day month and year herein above mentioned set their hands to this agreement in the presence of the following two witnesses.

College represented by its

Principal **PG Student**

Witnesses

1. **Student Guide**
2.

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INTRODUCTION

Bite force in dental context can be termed as the force exerted by masticatory muscles upon occlusion.[1] Bite force is the result of coordination between different components of masticatory system which includes muscles, bones and teeth.

Occlusal Bite Force (OBF) is the key predictor to assess the functional status of occlusion or the masticatory performance.[2] Bite force results from the action of the jaw elevator muscles which is determined by the central nervous system and feedback from muscle spindles, mechanoreceptors and nociceptors modified by the craniomandibularbiomechanics.[3]

Significance of measuring the bite force

Knowledge about bite force is important, as this parameter has been used in dentistry for various reasons:

- To understand the underlying mechanics of mastication.[4]
- To evaluate the physiological characteristics of jaw muscles.[5]
- To study the effect of different physical factors such as gender, age, height, and weight on occlusal forces.[6]
- To provide reference values for studies on the biomechanics of prosthetic devices.[7]

- It is clinically important in the assessment of the performance and therapeutic effects of prosthetic devices.[8]
- In the diagnosis and treatment of temporomandibular disorders.[9]

Occlusal disturbances that happen during orthodontic treatment are likely to disturb OBF, and evaluating the same will enable us to understand the changes of the stomatognathic system during treatment, especially in patients with different vertical facial morphology and may indicate steps to be taken to minimise disturbances, like reducing force levels and discomforts and thereby improving the quality of masitcation.

Optimum bite force values

It has been reported that a wide range of maximum bite force values exists. The mean maximum bite force values for intact dentition group were found to be 532 Newton (N) (ranges between 450N to 600N).[10] However there are various factors that may influence bite force values. The great variation in bite force values depends on many factors related to the anatomical and physiologic characteristics of the subjects. Instrumentation design and transducer position related to dental arch, may also influence the bite force values.[3]

Factors influencing Bite force

It was noted that short face individual have higher and long face individual have a lower maximum biting force than those with normal vertical dimension.[11,12] The normal aging process may cause the loss of muscle force. Bite force increases with age and stabilized only after puberty.[13] Maximum bite force is higher in males than females.[14] Reduced periodontal support may decrease the threshold level of the mechanoreceptors function causing changes in biting force.[15] The greater bite force in the posterior dental arch may also be dependent on the increased occlusal contact and the number of posterior teeth loaded during the biting action.[16]

Bite force changes in Malocclusion condition

A relationship between the Maximum Voluntary Bite Force (MVBF) and malocclusion is said to exist. It has been reported in many studies that the MVBF is often reduced in subjects with malocclusion.[17] MVBF was assessed in adult subjects with different forms of malocclusions and compared to that of control subjects with normal occlusions. The authors concluded that the MVBF significantly correlated with the vertical facial morphology whereas a weak correlation was found between the MVBF and the malocclusions which are linked to the sagittal facial morphology. Greater bite force found in individuals with normal occlusion, followed by Classes I, II and III, malocclusion respectively.[18] Reduction in MVBF could be attributed to the reduced number of occlusal contacts. Children with a unilateral posterior cross bite have been shown to have reduced maximum bite force and a reduced number of occlusal contacts compared with children possessing normal occlusions.[19]

Bite force and Orthodontic treatment

It was found that occlusal bite force increased after orthodontic treatment.[20] However, the maximum OBF has been shown to decrease during the course of orthodontic treatment.[21] Pain and discomfort of due to orthodontic appliances and changing occlusal relationships during orthodontic treatment produced a reduction in occlusal bite force during and after presurgicalorthodontics.[22]

While changes in bite forces have been shown to occur during routine orthodontic treatment, and that bite forces vary with varying facial patterns, there is no clarity whether the change in bite force during orthodontic treatment is same for all patients or if it differs with different types of facial patterns. Understanding the range of bite force changes during orthodontic treatment will enable us to understand the changes of the stomatognathic system during treatment and such an understanding is likely to help us identify the marked deviations and take steps to alleviate causative agents and thereby improve quality of mastication even during orthodontic treatment. Therefore this study was done to find the changes in bite force levels of patients with different facial types during orthodontic treatment.

AIM & OBJECTIVES

AIM

Primary aim

To assess the changes in maximum voluntary bite force during the first 6months of fixed appliance orthodontic treatment in patients with different vertical facial morphology.

Secondary aim

Compare and assess deviation of bite force in malocclusion patients with different facial types with the optimal bite force value estimated in individuals with acceptable occlusion and of different facial types.

OBJECTIVES

- To measure the occlusal bite force in Newtons (N) at
- T_0 pre treatment (baseline value).
- T_1: one week after bonding.
- T_2 to T_7: at end of every month from first to the 6^{th} month of orthodontic treatment.

- To verify if the base line bite force is achieved in individuals with different vertical facial morphology after the alignment and leveling stage, as reported earlier.
- To determine whether correction of overbite discrepancies (deep bite/ open bite) and alignment of teeth improves bite force.
- To compare bite force of individuals of varying facial types with and without malocclusion.

REVIEW OF LITERATURE

The available relevant literature has been reviewed utilizing different search engines in order to reach reasonable knowledge about what is known and what is still debatable about bite force and influential factor including the malocclusion and its treatment progression.

Black (1861)[24] president of the Chicago dental university in order to determine the average strength of the jaws devised an instrument of very simple design but with the name that would put the average jaw to a severe test, the gnathodynamometer. With this instrument, he tested the bite strength of a thousand people. The average shows 171 pounds for the molar teeth and much less for the bicuspids and incisors.

Linderholm & Wennstrom (1970)[53] stated that one force potentially responsible for low bite force in pain owing to the fact that carious teeth can cause high level of pin, particularly when the diseases is advanced. This then weakens bite strength.In this regard, this is also noted that a greater value of dmfs/dmft goes hand in hand with a low level of bite force, which provides a statistically significant negative link.

Lindqvist & Ringqvist (1973)[26] took bite force measurments so as to investigate bruxism – related factors in the case of children.

Helkimo et al (1975)[52] assessed the link between the state of dentition and bite force by taking a sample of 125 individuals aged 15-65 years. For the entire sample the maximal bite force range was 10-73 Kg with the authors highlighting that the presence of a decline in bite force values was found to be in line with increasing age particularly in the case of females with the further statement that a variation in bite force value could be linked with dental condition difference amongst participants. It was further concluded that bite force magnitude may be as much as five times greater in younger people with natural dentition when contrasted alongside older denture wearers.

Proffit et al (1983)[44] showed a link between facial vertical morphology and bite force low magnitude, in addition to weaker mandibular elevator muscles particularly, however, it should be recognized that the link was highlighted in studies with adults.

Williams et al (1987)[51] recognised that there will be an effect on the mechanoreceptors function where periodontal support is found to be lower owing to disease impacting the periodontium.

Kampe et al (1987)[10] examined bite force magnitude and occlusal perception with a sample of 29 young adults aged 16-18. Some with and some without dental fillings. The sample was divided into intact dentition group and fillings group. It is acknowledged that the fillings were mainly minor posterior teeth restorations. Accordingly the mean maximum bite force values for intact dentition group were found to be 532N. while the recorded mean for participants in the dental fillings group was 516N . Notably, however such differences were not considered to be statistically significant. Although it was recognized as valuable that subjects with intact dentition had a notably greater anterior bite force when contrasted with mean values in the fillings group.

Ow et al (1989)[30] recognized bite force as being one of the essential elements involved in the chewing function and is regulated by the “dental,muscular,nervous and skeletal system and exerted by the jaw elevator muscles”.

Bakke et al (1990)[38] investigated bite force in a sample of 8-68 years old males and females, subsequently concluding that bite force increase with age until females are 25 years old and males are 45 years old, at which point a decline is experienced.

Kiliaridis et al (1993a)[6] similarly carried out a cross –sectional research with a sample of 136 subjects divided in to subgroups, with a total age range of 7-24 years.

Kiliaridis et al (1993b)[37] studied the link between bite force magnitude and facial morphology in the case of 136 individuals aged 7-24, with subject's facial morphology determined through assessing different variables from standardized photographs, markedly, only slight positive links were established between incisor maximum bite force and upper facial height/lower facial height ratio.

Braun et al (1995)[13] stated that there is also an effect demonstrated through maxilla-facial growth. In this regard, it is believed that variation in maximum bite force magnitude is witnessed following changes in the cranio-facial growth, which complements normal growth process in addition to the growth of masticatory muscles.

Goldreich et al (1994)[66] who suggested that orthodontic adjustments tended to reduce functional muscle activity. This was explained by transient changes in occlusal support, periodontal mechanoreceptor effects and jaw elevator muscle reflexes.

Julien et al (1996)[32] measured bite force, contrasting masticatory efficacy in sample of 47 children and adults. Notably, the numerous variable in the group were discussed, with the explanation subsequently provided that the contact areas in posterior teeth in occlusion were strong determinants of masticatory performance. Furthermore, it was found through regression analysis that the individual with greater contact areas performed more efficiently than their counterpart of same gender and body build but with fewer contact areas. They also emphasized that the total available surface area cannot be considered a strong indicator of contact area, with this same notion supported earlier by **Yukstas et al (1965)**.[40]

Stewart et al (1997)[57] that fixed appliances create more pain when compared with removable appliance. Patients wearing fixed appliances reported higher values for intensities of pressure, tension, pain, and sensitivity to teeth.

Tortopidis et al (1998a,b)[16, 53] said that considering factors affecting bite force recognized that the position at which the recording device is placed within the oral cavity differs. Commonly, strong bite forces are normally recognized in the dental arch’s posterior region, as has been acknowledged through two different theories .First and foremost the mechanical lever system of the jaw; and secondly, posterior teeth (premolar and molars) are able to withstand greater force than anteriors.

Shinogaya et al (2001a)[14] conducted one research study examining ethnicity in regard to maximum bite force by taking a sample of 46 participants and dividing them according to ethnicity Danish (Caucasians). Japanese (Asians). With age and gender also taken into account. The authors subsequently found no significant link. It must be mentioned that amongst their inclusion criteria was the absence of dental fillings or disease including malocclusion. Therefore, they were comparing two ethnic groups with comparable dental status.

Sonneson et al (2001a)[25] examined bite force, TMD and facial morphology across a sample of pre-orthodontic children aged 7-13 years. It was established through their exploratory research studies that there was the presence of an association between muscles tenderness, long face and lower maximum bite forces, although such a link was recognized as being low to moderate.

Rentes et al (2002)[33] established bite force in 30 primary dentition children, with the sample split amongst three subgroups according to occlusion (normal occlusion, cross bite and open bite),with the authors subsequently highlighting that there were no prominent influences of malocclusion on bite force.

Sonnesen et al (2001b)[39] took note of maximum bite forces, utilizing this information to examine the link between craniofacial morphology temporomandibular dysfunction and head position. Children who were due to receive orthodontic treatment made up the study sample.

Julien et al (1996)[32] established that in addition to functional occlusal contact area and body build,maximum bite force explained approximately 72% of the variation in masticatory performance and efficiency among adults and children 212 primary school children,were assesed and concluded the link between nutrirional status and decay prevalance,obviously,a weight and body mass index was used as the measure to suggest overal child health ,with each child also interviewed.

Hatch et al (2001)[2] highlited that bite force has a strong link with masticatory performance, although the effects of such are not recognized as being as strong as the number of functional teeth.

Rentes et al (2002)[33] described chewing as a function that is developed and matures with time through learning experiances: thus,it is seen to be a fundamental aspect of the overall food intake process ,with bite force further recogniced as being a prominant determinant of chewing function and efficiency,exerted by jaw elevator muscles. skeletal and dental systems accordingly. such systems status will have a significant impaction on the bite ability and subsequently on chewing performance.

Sonnesen and Bakke (2005)[36] stated parallel findings group of 7-13 year old children, remarking that occlusion Angle's classification does not impact the levels of bite force, although they do recognize that lower bite force values were found amongst individuals experiencing class III malocclusion. This was supported by **Lemos et al (2006)**[45], who stated that the occlusion variable in their 36 subject sample was not found to impact bite force magnitude.

Kamegai et al (2005)[43] in contrast, examined bite force across a large sample of Japanese subjects with occlusion examined, amongst other variables, and participants classified in relation to the presence of normal occlusion, protrusion of the maxilla, crowded arches, crossbite. In both genders, bite force was found to reduce with the presence of any category of malocclusions. Furthermore, statistical significance as a result of the negative impact of malocclusion was found in children over 9 years, with the researchers further stating that bite force had a positive correlation with normal occlusion.

Sonnesen and Bakke (2005)[36] stated consensus that bite force commonly increase with age until the individual is approximately 20 years old, at which point there will be stabilized bite force. However, uponreaching 40 years bite force begins to decrease.

Sonnesen and Bakke (2005)[36] highlights the presence of a link between bite force and cranio-facial morphology, but only in the case of males aged 7-13. As such, the most fundamental of considerations in regard to craniofacial morphology impacting boy's bite force was the vertical jaw relationship. Thus, it can be stated that males with a shorter, lower facial height demonstrated a greater degree of force in bite.

Sonnesen and Bakke (2005)[36] state that the recognized increase in bite force, which has come to be linked with growth following their consideration of a sample aged 7-13 years, may be due to dental development in regard to increased dental eruptions; thus, an increased number of erupted teeth, it is expected that there will be greater bite force.

Toro et al (2006)[35] took into account in regard to the ability to break food. It was suggested that malocclusion was known to reduce masticatory performance, although such an effect was recognized as being relatively minor.

Toro et al (2006)[35] in this regard highlighted negative finding, stating that there were no statistically significant differences amongst boys and girls aged 6-15 in regard to their capacity to masticate food: however **Julien et al (1996)**[32] emphasized that young males demonstrated greater efficiency when masticating artificial food when compared to females.

Alkan et al (2006)[50] drew a comparison between participants with healthy periodontal tissues with those with chronic periodontitis, considering bite force. The authors underlined a remarkable relationship between bite force and periodontium health, with a significantly higher bite force amongst healthy subjects than those with periodontitis.

Pizolato et al (2007)[47] state that there is a negative impact of TMJ disorders and muscles pain on bite force recorded values . Likewise the same link was acknowledged by **Kogawa et al (2006)**[49]. Although **Pereira et al (2009)**[48] reports illustrate no significant impact as a result could be attributed to variation in recording techniques as well as variation in severity of TMD cases studied in different studies.

Calderon et al (2006)[27] carried out a research study concerned with investigating adult cases of bruxism, with bite force assesments used through the study approach.

Castelo et al (2007)[42] considered the link between occlusal contacts, masticatory muscles thickness and bite force values by taking a sample of 46 child subjects. Each of whom was assigned to a group in regard to the dentition stage and their occlusion. The researches highlighted a strong positive link between thickness of the masseter muscle and maximum bite force amongst children with normal occlusion.

Mountain (2008)[23] in a PhD thesis did analyse ethnicity effects with a statistically negative correlation (r=-0.17.<0.01) for Asian origin and maximum bite force in young children. In contrast there was a positive statistically significant link between individuals of black origin and maximum bite force (r=1.2, p<0.05).

Rismanchian et al (2009)[28] said in record to adult dentistry that implant success is assessed in consideration of various factors namely chewing ablity, biting ability, and functional recording,which provides one aspect of bite force determination clinical use.

Koc et al (2011)[34] stated that cranio-facial morphology description includes the ratio between anterior and posterior facial heights, inclination of the mandible, and gonial angle. The researchers further added that maximum bite force suggests that –mandible's lever systems geometry.

Castelo et al (2007)[42] examined maximum bite force and its link with facial morphology by taking a sample of 67 young children aged 3.5-7 years, all of whom had posterior crossbite.It was stated through the conduction of univariate analysis in the mixed dentition stage that the subjects found to have lower bite forces were markedly more vulnerable to exhibit posterior crossbite, although this could not be recognized as an indicator for the presence of crossbite as multiple logistic levels did not be recognized as an indicator for the presence of crossbite as multiple logistic levels did not illustrate significant levels. It was further emphasized that bite forces in mixed-dentition children with posterior crossbite were markedly lower when compared against those with normal mixed dentition occlusion. They further added that such a difference was due to differences in masticatory cycle duration, length of lateral excursion, combined with impaired muscles function. It is recognized that all of these elements may result in neuromuscular adaptation so as to avoid any tooth interferences.

Koc et al (2010)[3] said that the evaluations of bite force have been proven to be constructive and thus widely utilized in dentistry, with the measurement of such conducted with the aim of determining muscular activity and jaw movements during the chewing process as stated by **Bakke et al (1992)**[31] with measurements also valuable in terms of masticatory evaluation as supported by the work done by **Julien et al (1996)**[32].

Mountain et al (2011)[41] found that there were lower bite forces in children with primary dentition malocclusion (194.2N) when compared with those of normal primary occlusion (197.10) although this difference was not statistically significant.

Van der Built (2011)[29] stated that there are numerous elements known to impact masticatory performance, including age, bite force, gender, the loss and type of restoration of post canine teeth, malocclusion, total area of teeth in contact oral motor function and salivary glands function.

Mountain et al (2011)[55] stated that the maximum bite force exerted by primary dentition children can be predicted by the number of decayed, missing and filled teeth surfaces. In this regard , it was noted that a significant negative relationship between DMFS and maximum bite force suggested that a child with deteriorated dentition was potentially more likely to demonstrate weaker bite forces when contrasted with a child with a healthy normal dentition. The author emphasised that bite force at the primary stage of dentition development may ultimately depend on caries prevalence.

Fernanders et al (2003)[56] quotes that the majority of modern designs utilize electrical resistant strain gages overall the majority of recording tools concerned with the bite force have the potential to record forces between 0 and 800N at a rate of 80% precision and accuracy amounting to 10 N.

Rentes et al (2002)[33] **and Castelo et al (2007)**[42] used a pressurized rubber tube as a bite force device that must be connected to sensor element (pressure sensor MPX 5700 Motorola) There is the need to connect the system to the computer and software so as to enable pressure reading and thus establishing the values in psi .However, the disadvantage that the Psi must then be converted to N, taking into consideration the tube area due to the fact that force equals pressure multiplied by area which would markedly impact the easiness such as utilization and thus make it less practical. In addition there is also the need to connect to a computer, and so it may be recognized that the device is not portable.

Another recording system utilized in the context of bite force is dental prescalesystem, which comprises a horse-shoe shaped bite foil made from a pressure –sensitive film, and further includes a computerized scanning system, which is able to analyze the applied forces. Upon the application of force to the occlusal surfaces a graded colour will be reaction from chemical reaction.

Koc et al (2010)[3] stated that the exposed pressure sensitive foils are analyzed in the occlusal scanner which reads the area and colour intensity of the red dots to assess occlusal contact area and pressure, with occlusal load anatomically analysed.

Shinogaya et al (2000b)[46] assessed bite force with the use of dental prescale system, stating that it has the benefit of measuring bite forces at intercuspal position, and accordingly delivering prediction of bite forces under natural conditions, moreover the force distribution can also be assessed simultaneously, although there is a technical limitations in terms of the computerized scanning apparatus, as highlighted previously.

Sonnesen & Bakke (2007a,b)[19,59] have measured OBF before and after orthodontic treatment and reported that there is an increase in the bite force value after correction of unilateral cross bite.

Abu Alhaija (2010)[58] Occlusal bite force has been shown to vary in patients with different vertical facial morphological characteristics. Occlusal bite force is greater for hypodivergent individual followed by normodivergent and less for hyperdivergent individuals.

Koc et al (2011)[34] Recognised bite force as one of the factors including masticatory system’s functional state resulting from jaw elevator muscle action, modified by cranio- mandibular biomechanics.

Varga et al (2011)[60] found that there was minimal increase in bite force following the cessation of the pubertal growth spurt. Maximum voluntary bite increase with age and it stablises after reaching pubertal growth spurt.

Sawsan et al (2012)[69] stated OBF reduced during the first month of orthodontic treatment but, with time, recovered to pretreatment levels. 50% of pretreatment OBF was lost by the end of the first week. OBF showed a tendency to return to pretreatment levels after the second month of orthodontic treatment.VAS scores were high during the first 2 weeks of appliance treatment.

In the present review we have gathered insights in to how bite force has been shown to be affected by a number of physiological and morphological variables. Other variables such as state of dentition, instrumentation design and transducer position related to dental arch, malocclusions, signs and symptoms of temporomandibular disorders, size composition and mechanical advantage of jaw closing muscles, may also influence the values found for his force.

MATERIALS AND METHODS

Study armamentarium

- Separators (JJ Orthodontics) and separator placing plier
- Materials for banding and bonding (Ormco, 3M Unitek)
- MBT 022 Orthodontic bracket kit (3M Unitek Gemini)
- Arch wire (JJ Orthodontics)

  NiTi Preformed Archwires: Upper and Lower 0.014 NiTi, 0.016” NiTi, 0.017x0.025 NiTi, 0.019x0.025 NiTi

  Stainless Steel Preformed Archwires: Upper and Lower 0.016 SS, 0.018 SS, 0.017x0.025 SS, 0.019x0.025 SS (**Fig. 1**)
- Strain gauge transducer (Hari Om Electronics, Gujarat)
- Disposable latex cot

Study area

Department of Orthodontics and Dentofacial Orthopaedics, Government Dental College and Hospital, Chennai, Tamilnadu.

Study population

14-24 yrs old outpatients undergoing orthodontic treatment in the Department of Orthodontics and Dentofacial Orthopaedics, Government Dental College and Hospital, Chennai, Tamilnadu were included in the study group.

Study period

The study was performed for the period of six months during the alignment and leveling stage of the fixed orthodontic treatment.

Type of study **:** Cross Sectional study.

Type of sample **:** Consecutive sampling.

Sample size **:** 30 subjects as group study (A) and 30 subjects, who possessed normal occlusion and with the three different facial types was selected as control group (B). Each subject group was divided into three sub groups with 10 subjects in each. Thus group A was divided as follows:

A_1 - Hypodivergent individual

A_2 - Normodivergent individual

A_3 - Hyperdivergent individual

Similarly the control group (B) was divided into three sub groups with 10 subjects in each. Thus group B was divided as follows:

B_1 - Hypodivergent individual

B_2 - Normodivergent individual

B_3 - Hyperdivergent individual

Subjects Selection criteria

Inclusion criteria

- ✓ Healthy individuals with full complement of teeth.
- ✓ Age group : 14 to 20 years,
- ✓ Either sex.
- ✓ Mild to moderate crowding/ bimaxillary dentoalveolar proclination.
- ✓ Patients willing for voluntary participation and have signed informed consent.

Exclusion criteria

- ➢ No prior orthodontic treatment.
- ➢ No posterior cross bite.
- ➢ No signs and symptoms of Temporal Mandibular Joint (TMJ) dysfunction.
- ➢ No large carious lesions or restoration.
- ➢ Patients with Periodontal compromised teeth.

- Patients with deleterious oral habits like bruxism, tongue thrust *etc*.
- Patients with jaw discrepancy requiring surgical correction.
- Patients with oral manifestation of systemic disease.
- Patients with no previous H/O trauma to the face and the jaws.

Study design

Ethical approval for the present study was obtained from the Institutional ethics committee of Tamil Nadu Government Dental College and Hospital, Chennai.. Patients attending the orthodontic outpatient clinic, Department of Orthodontics and Dentofacial Orthopaedics, Tamil Nadu Government Dental College and Hospital, Chennai, Tamilnadu were screened. 30 patients (19 females, 11 males) who fulfilled the above criteria formed the study group (A) and the control group (B) with normal occlusion were categorized according to their facial types into three sub groups, as mentioned earlier was selected.

The participant's information sheet (English and Tamil) was given to all the patients involved in the study, and the informed consent was obtained from patients or guardians. All the subjects selected for the study underwent general examination, intra oral examination and extra oral examination.

Study methodology

The required pretreatment radiographs and study model were taken for all subjects included in the study. The diagnosis and treatment plan was established for all the subjects. Orthodontic treatment was started with 0.022 slot MBT prescription brackets and banding of the first and second molars in both upper and lower arches. Neither extra-oral appliances nor maxillary expansion devices were used for any of the patient (**Fig. 1**). The sequence of change of arch wires was as follows: 0.014 Ni-Ti, 0.016” NiTi, 0.016” SS, 0.018” SS, 0.017 x 0.025 Ni-Ti, 0.017x0.025 SS, 0.019x0.025 NiTi, 0.019x0.025 SS.

Occlusal bite force (OBF) measurement was performed for all the subjects included in the study. The control group (B) was also examined in order to provide comparative occlusal bite force levels over a period of six months. But control group (B) values were not included in the statistical analyses. Occlusal bite force was recorded in these subjects on six separate occasions with an interval of one month between measurements.

Data collection

Occlusal Bite Force was recorded for the study group (A) at the following time intervals:

T_0: Just prior to orthodontic elastic separator insertion.

T_1: One week after the placement of orthodontic appliances.

$T_2 - T_7$: the bite force was recorded at the end of every month from the first month after starting to the sixth month, before the scheduled arch wire change for that visit if any.

Occlusal Bite Force was recorded for the control group (B) at T_2 to T_7 on six separate occasions with an interval of one month between measurements, as they did not undergo fixed orthodontic treatment.

Bite force measurement procedure

Bite force was measured using a "STRAIN GAUGE TRANSDUCER-Digital bite force meter". This gadget uses electronic technology and comprises a bite plate and body (**Fig. 2**). The gadget presents a scale in which measures force in Newtons (N).

The specifications for the device are

- Force range:0-1000N
- Accuracy: +/- 2 N
- Size : Biting element: 6x4 cm
- Display body: 25x20 cm

Bite force measurement procedure was done in accordance with the procedure adopted by Mountain, 2008. The biting forks of the strain gauge transducer were covered with the polymeric material to prevent any damage to the tooth structure and is encased in disposable latex finger cot to protect the individual from cross contamination. The individuals were seated in an upright position and instructed to bite as hard as possible on the biting fork and the force value displayed in monitor of the gadget, as Newton was noted (**Fig. 2**).

OBF as explained previously was measured bilaterally in the first permanent molar region. Before recording, each subject was instructed to sit upright, look forward without back support and with the Frankfort Horizontal plane parallel to the floor. The load cell unit was placed parallel to the occlusal plane. Each subject was instructed to bite on the biting element which is a metal covered by polymeric material encased in a disposable latex finger cot. The patient was asked to bite as hard as possible without moving their head.

Three OBF measurements will be recorded on each side with a 15 second rest between each bite. The maximum OBF measurement achieved on each side was taken as the bite force value. The average maximum OBF is considered as the occlusal bite force (OBF) for that patient included in the analysis.

Figure 1. A. Materials and B. Instruments used during the fixed orthodontices treatemt.

Figure 2. A. OBF measuring device and B. Bite force recorded in a subject.

Analysis of the data

Statistical analysis was performed using the Statistical Package for the Social Sciences computer software (SPSS 21.0, SPSS Inc., IL, USA). Shapiro-Wilks test was carried out to assess the normality of OBF data collected during the study.

Descriptive statistics was performed for OBF values recorded in study group (A) at different time intervals. The repeated measures analysis was used to test hypotheses about the means of a dependent variable when the same dependent variable is measured on more than one occasion for same subject.

The repeated measures analysis of variance (within-subjects ANOVA) test with a Greenhouse-Geisser correction and Bonferroni post-hoc comparison were conducted to examine and define the differences in means of OBF measured at the different time intervals before and during orthodontic treatment. All statistical analyses were carried out at $p \leq 0.05$ level of significance.

RESULTS

The overall summary results from two well-known tests of normality, namely the Kolmogorov-Smirnov Test and the Shapiro-Wilk Test is given in Table-1. The Shapiro-Wilk Test is more appropriate for small sample sizes (< 50 samples), but can also handle sample sizes as large as 2000. Hence, the Shapiro-Wilk test was taken for the present analyses of numerical means for assessing normality.

The Significance value of the Shapiro-Wilk Test is greater than 0.05, in most of the data, so the data is normally distributed. It is below 0.05, at time interval T_1, T_4 and T_7 in A_1 group and in A_3 group at time T_4, these four data significantly deviate from a normal distribution.

Descriptive statistics for OBF scores at the different time intervals before and during fixed orthodontic treatment for hypodivergent study group (A_1), normodivergent study group (A_2) and hyperdivergent study group (A_3) were program calculated and provided in Table 2-4. The minimum and maximum OBF recorded at time T_1 and T_0 in A_1 group was 131.33N and 568.33N, in A_2 group was 109.33N and 517.00N and in A_3 group was 114.67N and 398.00N respectively.

Table - 1. Overall summary of Shapiro-Wilk test of normality.

Tests of Normality							
Time	**Study Group**	**Kolmogorov-Smirnov[a]**			**Shapiro-Wilk**		
		Statistic	**Df**	**Sig.**	**Statistic**	**Df**	**Sig.**
T_0	**A_1**	.277	10	.029	.878	10	.123
	A_2	.246	10	.088	.882	10	.136
	A_3	.209	10	.200*	.950	10	.665
T_1	**A_1**	.278	10	.028	.785	10	.010
	A_2	.186	10	.200*	.949	10	.652
	A_3	.220	10	.187	.846	10	.051
T_2	**A_1**	.145	10	.200*	.914	10	.309
	A_2	.161	10	.200*	.980	10	.963
	A_3	.171	10	.200*	.917	10	.329
T_3	**A_1**	.203	10	.200*	.902	10	.232
	A_2	.157	10	.200*	.974	10	.928
	A_3	.139	10	.200*	.983	10	.979
T_4	**A_1**	.262	10	.050	.841	10	.045
	A_2	.242	10	.099	.862	10	.081
	A_3	.253	10	.069	.794	10	.012
T_5	**A_1**	.184	10	.200*	.913	10	.301
	A_2	.148	10	.200*	.971	10	.897
	A_3	.193	10	.200*	.888	10	.160
T_6	**A_1**	.216	10	.200*	.882	10	.137
	A_2	.150	10	.200*	.940	10	.558
	A_3	.131	10	.200*	.984	10	.984
T_7	**A_1**	.263	10	.048	.802	10	.016
	A_2	.172	10	.200*	.923	10	.381
	A_3	.197	10	.200*	.903	10	.238
*. This is a lower bound of the true significance.							
a. Lilliefors Significance Correction							

Table - 2. Summary of descriptive statistics for hypodivergent study group (A_1)

Time	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
T_0	10	257.66	310.67	568.33	469.4010	69.22570	4792.197
T_1	10	155.67	131.33	287.00	191.6670	62.89467	3955.739
T_2	10	176.33	127.67	304.00	230.6010	60.93878	3713.534
T_3	10	141.67	226.00	367.67	275.2680	42.41736	1799.233
T_4	10	128.33	246.00	374.33	306.5990	52.20214	2725.064
T_5	10	130.00	257.67	387.67	320.6010	48.07445	2311.152
T_6	10	121.67	266.00	387.67	343.9010	42.77007	1829.278
T_7	10	140.67	292.00	432.67	389.2000	38.59475	1489.555
Valid N (listwise)	10						

Table - 3. Summary of descriptive statistics for normodivergent study group (A_2)

Time	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
T_0	10	137.67	379.33	517.00	435.9330	48.47343	2349.673
T_1	10	89.34	109.33	198.67	160.0330	28.80967	829.997
T_2	10	97.33	176.67	274.00	227.5350	27.38528	749.953
T_3	10	64.00	250.00	314.00	282.1320	20.09638	403.864
T_4	10	68.67	296.00	364.67	321.9340	25.40522	645.425
T_5	10	75.66	312.67	388.33	349.9330	24.67102	608.659
T_6	10	71.33	338.00	409.33	378.1980	23.66681	560.118
T_7	10	67.00	373.33	440.33	400.4010	22.30354	497.448
Valid N (listwise)	10						

Table - 4. Summary of descriptive statistics for hyperdivergent study group (A_3)

Time	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic
T_0	10	92.00	306.00	398.00	348.8670	28.15573	792.745
T_1	10	10.66	114.67	125.33	120.0320	44.0761	19.427
T_2	10	83.00	179.00	262.00	208.7000	26.95377	726.506
T_3	10	64.00	207.00	271.00	241.1340	17.58255	309.146
T_4	10	82.33	215.00	297.33	274.5330	28.31753	801.882
T_5	10	46.00	271.67	317.67	270.7000	17.11105	292.788
T_6	10	61.66	295.67	357.33	325.7000	19.02418	361.919
T_7	10	75.00	307.00	382.00	354.7670	25.50247	650.376
Valid N (listwise)	10						

Table - 5. Compression of occlusal bite force (Newton) measured at different time intervals in hypodivergent study group A_1 and the control group B_1 before and during fixed orthodontic treatment (n = 10).

Time interval	**Control Group (B_1) OBF (N)**	**Study Group (A_1) OBF (N)**		
	(Mean±SD)	(Mean±SD)	Loss (%)	Recovery (%)
Before (T_0)	-	469.40±69.23*	-	-
1st week (T_1)	-	191.67±62.89*	59.17	-
1st month (T_2)	580.30±162.53	230.60±60.94	50.87	14.02
2nd month (T_3)	575.28±146.33	275.27±42.42	41.36	30.10
3rd month (T_4)	566.20±154.19	306.60±52.20	34.68	41.38
4th month (T_5)	579.60±149.56	320.60±48.07	31.70	46.42
5th month (T_6)	563.10±145.35	343.90±42.77	26.74	54.81
6th month (T_7)	589.40±132.73	389.20±38.59	17.09	71.12

*denotes significance $p<0.05$ level

The mean OBF, standard deviation and percentages of OBF loss and recovery during orthodontic treatment at the different time intervals for control and study hypodivergent group (B_1 & A_1), normodivergent group (B_2 & A_2) and hyperdivergent group (B_3 & A_3) are shown in Table - 5, Table - 6 and Table - 7 respectively.

From the repeated measures ANOVA **(**Within-Subjects) table, the *F* value is calculated for the "time" factor, its associated significance level and effect size ("Partial Eta Squared"). The values in the "Greenhouse-Geisser" row were taken in account for the overall comparison of statistical significant with different study groups (A_1, A_2, and A_3). The Post hoc tests using the Bonferroni correction, Tests of Within-Subjects effects table was used to study the overall significant difference between the means at the different time points (T_0 to T_7) by pairwise comparison.

A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean OBF differed statistically significant between time points in study group (A_1), the mean scores for OBF in study group (A_1) were statistically significantly different (F (3.133, 28.196) =75.335, $p < 0.0005$). Post hoc tests using the Bonferroni correction revealed that in the study group A_1 there was no significant difference in OBF between time T_1 and T_2 (p =0.301), T_2 and T_3 (p =0.264), T_3 and T_4 (p =0.232), T_4 and T_5 (p =0.619), T_5 and T_6 (p =0.063), and

T_6 and T_7 (p =0.072), remaining time points are significantly differed at p<0.005 level.

The mean OBF in B_1, B_2 and B_3 control group was 580.30±162.53N, 536.30±162.53N and 480.30±162.53N respectively. The mean OBF in A_1, A_2, A_3 treatment group was 469.40±69.23 N, 435.93±48.47 N and 348.87±28.16 N respectively ($p < 0.005$). No significant differences in OBF magnitude were found over the six month period in the control group ($p > 0.05$).

A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean OBF differed statistically significantly between time points in study group (A_2), the mean scores for OBF in study group (A_2) were statistically significantly different (F (2.352, 21.164) = 132.064, $p < 0.0005$). Post hoc tests using the Bonferroni correction revealed that in the study group A_2 there was no significant difference in OBF between time T_0 and T_7 (p =0.307), remaining all time points are significantly different at p<0.005 level.

A repeated measures ANOVA with a Greenhouse-Geisser correction determined that mean OBF are statistically significantly different between time points in study group (A_3), the mean scores for OBF in study group (A_3) were statistically significant difference (F(2.370, 21.329) = 181.543, $p < 0.0005$). Post hoc tests using the Bonferroni correction revealed that in the study group A_3 there was no significant difference in OBF between time T_0 and T_6 (p =0.396), T_0 and T_7 (p =1.00) and T_2 and T_3 (p =0.340).

Table - 6. Compression of occlusal bite force (Newton) measured at different time intervals in normodivergent study group A_2 and control group B_2 and before and during fixed orthodontic treatment (n = 10).

	Control Group (B_2) OBF (N)	**Study Group (A_2) OBF (N)**		
Time interval	(Mean±SD)	(Mean±SD)	Loss (%)	Recovery (%)
Before (T_0)	-	435.93±48.47	-	-
1^{st} week (T_1)	-	160.03±28.81*	63.29	-
1^{st} month (T_2)	536.30±162.53	227.53±27.39*	47.81	24.47
2^{nd} month (T_3)	525.28±146.33	282.13±20.10*	35.28	44.26
3^{rd} month (T_4)	530.20±154.19	321.93±25.41*	26.15	58.68
4^{th} month (T_5)	528.60±149.56	349.93±24.67*	19.73	68.83
5^{th} month (T_6)	534.10±145.35	378.20±23.67*	13.24	79.07
6^{th} month (T_7)	532.40±132.73	400.40±22.30	8.15	87.12

*denotes significance p<0.05 level

Table - 7. Compression of occlusal bite force (Newton) measured at different time intervals in hyperdivergent study group A_3 and control group B_3 before and during fixed orthodontic treatment (n = 10).

	Control Group (B_3) OBF (N)	STUDY GROUP (A_3) OBF (N)		
Time interval	(Mean±SD)	(Mean±SD)	Loss (%)	Recovery (%)
Before (T_0)	-	348.87±28.16	-	-
1st week (T_1)	-	120.03±44.09*	65.59	-
1st month (T_2)	480.30±162.53	208.70±26.95	40.18	38.75
2nd month (T_3)	485.28±146.33	241.13±17.58	30.88	52.92
3rd month (T_4)	476.20±154.19	274.53±28.32*	21.31	67.52
4th month (T_5)	479.60±149.56	270.70±17.11*	22.41	65.84
5th month (T_6)	483.10±145.35	325.70±19.03	6.64	89.88
6th month (T_7)	474.40±132.73	354.77±25.50	-1.69	102.58

*denotes significance $p<0.05$ level

The patterns of OBF changes during orthodontic treatment at different time intervals (T_0 - T_7) for hypodivergent (A_1), Normodivergent (A_2) and hyperdivergent (A_3) treatment group are shown in **Fig. 3**. There was a significant difference in OBF values associated with the different time intervals ($p < 0.001$). The lowest reported OBF was at T_1. The highest reported OBF was at T_0 followed by T_7 for hypodivergent treatment group (A_1) and normodivergent treatment group (A_2) and highest OBF was at T_7 for hyperdivergent treatment group (A_3).

Percentage (%) Occlusal Bite Force loss and recovery at different time intervals in A_1, A_2 and A_3 study group patients, before and during fixed orthodontic treatment are represented in **Fig. 4**.

The Occlusal Bite Force loss percentage at T_1 is 59.17, 63.29 and 65.59 for hypodivergent, normodivergent and hyperdivergent treatment group respectively. The Occlusal Bite Force loss percentage at T_7 is 17.09, 8.15 and -1.69 for hypodivergent, normodivergent and hyperdivergent treatment group respectively. The bite force recovery percentage was high in all study groups at time T_7.

However the recovery percentage is greater for hyperdivergent study group (A3) of about 102.52%, 87.12% for normodivergent study group (A2) and 71.12% for hypodivergent study group (A1).

Figure 3. Changes in occlusal bite force (in Newton) at different time intervals in A_1, A_2 and A_3 study group, before and during fixed orthodontic treatment (n = 10; Error bars = S.D).

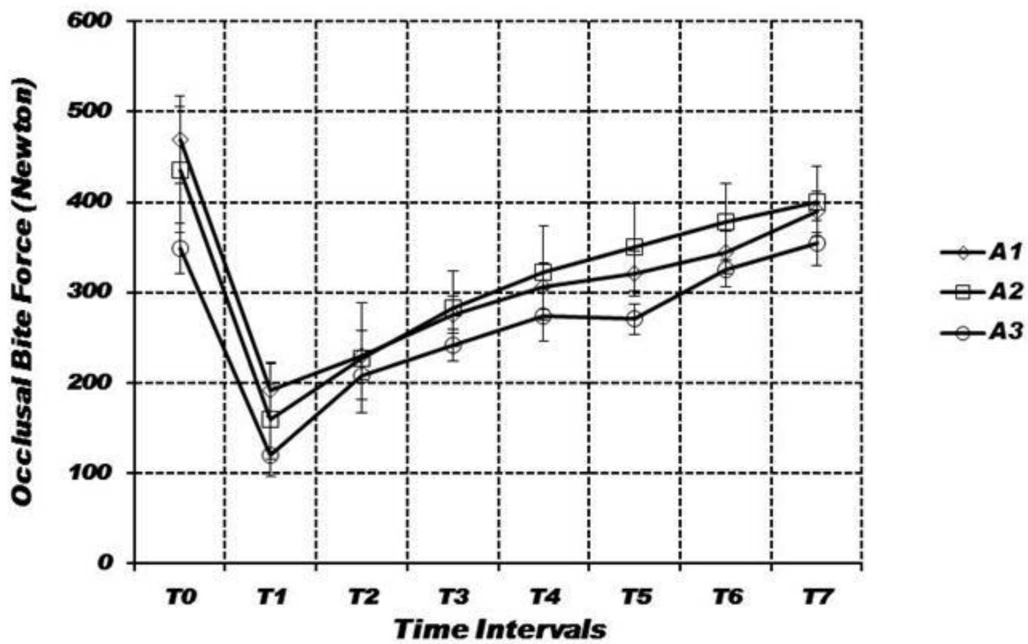
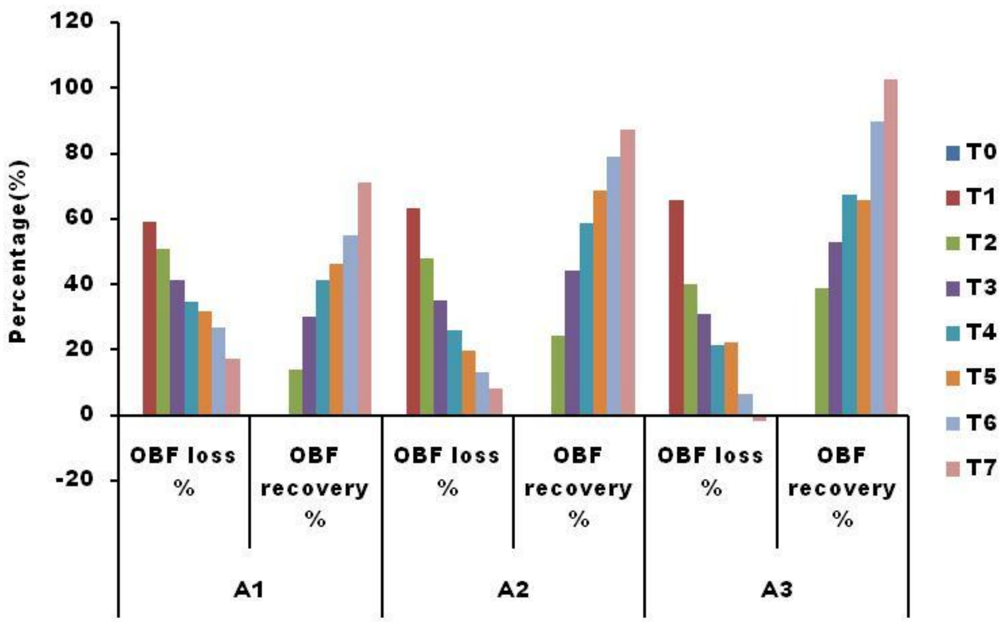


Figure 4. Percentage (%) occlusal bite force loss and recovery at different time intervals in A_1, A_2 and A_3 group patients, before and during fixed orthodontic treatment (n = 10).



DISCUSSION

Improvement of functional efficiency is one of the aims of orthodontic treatment. Biting efficiency is an important aspect of oral functions. Occlusal bite force is one of the parameters in assessing the biting efficiency and this force is likely to change during orthodontic treatment due to changes in interarch cusp and fossa relationships during tooth movement. Patients wearing fixed appliances reported higher values for intensities of pressure, tension, pain, and sensitivity to teeth as compared with those treated with removable orthodontic treatment, as observed by Stewart et al.[57] Hence bite forces are likely to be affected and masitcatory efficiencies are expected to be compromised during fixed orthodontic treatment.

Occlusal bite force has been shown to vary in patients with different vertical facial morphological characteristics.[58] Only few studies have addressed the issue of occlusal bite force changes during fixed appliance orthodontic treatment.[21, 22] Previous reports have measured OBF before and after orthodontic treatment[58] but have not reported OBF during treatment especially in patients with different facial morphology. In the present study, occlusal bite force changes during fixed orthodontic treatment in patient with different vertical facial morphology is analysed. In this study, OBF changes in a control group of subjects with normal occlusion and in study subjects who were undergoing orthodontic treatment, every month during the study period of six months was recorded. As no significant changes in OBF values were found in the control group over the six months, the changes in OBF measured in study subjects during this study were considered a result of orthodontic treatment.

In the present study Subjects aged 15 years and above were recruited as previous evidence suggested that OBF increases with age to stabilise after the age of 14 years. With physiological aging process the bite forces start declining from about 50 years of age. In children with permanent dentition between the ages of 6 and 18, bite force has been significantly correlating with age. However, Varga et al.[60] found that there was minimal increase in bite force following the cessation of the pubertal growth spurt.

Gnathodynamometers have been used to measure bite force for a long time and some investigators use strain-gauges mounted dynamometer for recordings.[61] Recently, deformation-sensitive piezoelectric film has been employed as a force detection recording system.[62] Another recording device is the dental prescale system which consists of a horse-shoe shaped bite foil of a pressure-sensitive film and a computerized scanning system for analysis of the load. When the force is applied to occlusal contact, a graded colour is produced by the chemical reaction. The exposed pressure-sensitive foils (PSF) are analyzed in the occlusal scanner. The scanner reads the area and colour intensity of the red dots to assess occlusal contact area and pressure. Finally, it calculates occlusal loads automatically.[63]

The present study employed a strain gauge transducer with a biting element encased in polymeric covering. The most widely accepted bite force recording device is the strain-gage bite force transducer.[3] The biting element is encased in a polymeric material which provides a comfortable surface for maximum bite force. Tortopidis et al[16] have used acrylic appliances in contact with the metal faces of the strain-gage transducers to minimize the risk of fracturing teeth when biting hard on the transducer. It had been reported that when the subject bites the hard metal surface of transducer, the neuromuscular reaction of subject generates irregular movements that prevent maximum bite force.

Malocclusions are often associated with reduced OBF.[17] In the present study, the OBF in the treatment group, each of which possessed a Class I malocclusion, exhibited lower OBF values prior to treatment, compared with a control group with acceptable occlusions. This supports previous findings which reported that masticatory performance is highest in subjects with Class I occlusions followed by Class I, Class II and Class III malocclusions in descending order.[18]

Maximum bite force varies with varying cranio-facial morphology. In the present study the OBF among the study group hyperdivergent facial morphology exhibited lower occlusal bite force and hypodivergent facial morphology exhibited higher occlusal bite force when compared to normodivergent facial morphology. This confirms the previous finding that short-faced people exhibit stronger bite force and the long-faced type of the cranio-facial morphology has been associated with smaller value of the bite force.[57]

A, a large reduction in OBF (50%) occurred at the end of the first week following the placement of separators. It is well-known that placement of orthodontic separators (brass wire, elastomerics, spring type steel separators, and latex elastics) results in a painful experience for almost all patients.[63] An electromyographic (EMG) study, performed to evaluate the motor and sensory changes associated with separator placement, showed a decrease in motor output as well as pressure pain threshold in muscles of mastication.[64] They suggested this to be a protective mechanism against further damage to the injured part of the masticatory system. It is clear that pain is associated with the process of orthodontic separation and starts within 4 hours of its placement with a peak level at day 2 that might last for 7 days.

The results of the present study confirmed those of Thomas et al.[22] who reported a reduction in OBF during treatment. In addition, the present results were supported by Goldreich et al.[66] who suggested that orthodontic adjustments tended to reduce functional muscle activity. This was explained by transient changes in occlusal support, periodontal mechanoreceptor effects and jaw elevator muscle reflexes. The reduction in OBF observed in the present study may be due to changes in occlusal contacts which occurred during treatment, as it was previously reported that occlusal contacts determine 10% to 20% of the variation of maximum bite force in adults.

OBF showed a tendency to return to pretreatment levels after the second month of orthodontic treatment in the present study. Pain associated with initial archwire placement has been previously researched. Jones (1984)[67] reported that pain is experienced by the majority of patients 4 hours after archwire placement, which will peak at 24 hours and then decline. The pain will usually last for 2 – 3 days and will gradually decrease in its intensity by fifth or sixth day. Smith et al[68] and Goldreich et al.[66], through different experiments, evaluated the effect of orthodontic archwire activation on the masseter muscle through EMG activity. They observed a reduction in masseter muscle activity and attributed this to the noxious stimuli emulating from the periodontal membrane or paradental receptors triggering a reflex mechanism, which caused inhibition of jaw-closing muscles.

In the present study, Bite force remained significantly reduced during the first week and in the first month and then gradually increased which may be due to reduction in the occlusal disturbances and increase in the pain threshold for the patients.

OBF shows a tendency to return to pretreatment level in treatment group at the completion of aligning and leveling stage of fixed orthodontic treatment. This may be due to the increase in the occlusal contact area by improvement in alignment of teeth and leveling the curve of spee and correction .This is in accordance to the previous studies which states that leveling the curve of spee increases the occlusal contact area of the posterior teeth.[69]

OBF shows a tendency to return to pretreatment in hyperdivergent treatment group and OBF reaches beyond the pretreatment level but is statistically insignificant.OBF showed a tendency to reach close to the pretreatment in normodivergent and hypodivergent treatment group. This may be due to the delay in the time interval during the alignment and leveling stage in hypodivergent vertical facial morphology. Researchers have suggested a significant correlation between bite force and muscle thicknesses and between masseter-temporal muscle thickness and facial morphology.[47] In this respect, Farella et al[12] have stated that masseter muscles are thicker in shortfaced subjects than in normal or long-faced subjects.

Ferrario et al[71] have observed that males have larger teeth size and a correspondingly larger periodontal area and therefore record a higher bite force as compared to females. In contrast, Wichelhaus et al[72] have studied the functional forces occurring during nocturnal sleep and found found no significant differences in bite force between males and females. They have suggested that it might be due to the small number of subjects included in their study. Even if some authors have found a non-significant gender effect, most studies have confirmed the differences of bite force values between males and females. OBF finding may be affected by gender was not an aim of this study.

LIMITATIONS

This study was done only during initial stages of aligning and leveling only. Further studies are recommended to check the bite force levels during and post orthodontic treatment also.

Further studies with larger sample sizes can be done for further affirmations and clarifications.

Yurkatas et al opines that in post orthodontics phase, muscle's ability to rebuild and strengthen increases, reversing the typical avoidance of tough foods that prevailed during active treatment time. Furthermore, as in the study of Bakke et al,[1] bite force correlated with the number of occlusal contacts and that the peak force was reached three months after debonding.

Considering these views, it also recommended that the bite force value be assessed in post orthodontic phase.

SUMMARY AND CONCLUSION

Occlusal Bite Force (OBF) is one of the important parameters to assess optimal functional status of occlusion or the masticatory performance. The OBF has been reported to differ with varying facial patterns. Changes in interocclusal relationships during orthodontic treatment do cause occlusal disturbances and are likely to disturb OBF. Evaluating the same in patients with different vertical facial morphology will enable us to understand the changes in their masticatory efficiency during treatment and would enable the clinician to take steps to minimise disturbances, like reducing force levels and discomforts and thereby improving the quality of mastication even during orthodontic treatment.

Therefore this study was done to assess the changes in maximum voluntary bite force during aligning and leveling stage of fixed orthodontic appliance treatment in patients with different vertical facial morphology and to Compare and assess deviation of bite force in malocclusion patients with different facial types with the optimal bite force value estimated in individuals with acceptable occlusion and of different facial types.

30 patients age group of 14-24 yrs, were divided in to 3 groups as hypodivergent, normodivergent and hyperdivergent groups and their OBF was recorded during the study period of six months and anlaysed.

From the findings observed in the study it can be concluded that

- OBF is altered due to fixed orthodontics.
- Occlusal bite force is reduced to 50% of the pretreatment level by the end of the first week of fixed orthodontic treatment.
- OBF showed a tendency to return to pretreatment levels after the second month of orthodontic treatment.
- Occulusal bite force is least, average and higher in hyperdivergent , normodivergent and hypodivergent individuals respectively, with or without orthodontic treatment.
- After aligning and leveling stage, the OBF reaches the baseline level in hyperdivergent treatment group, while it reaches close to pretreatment level in hypodivergent and normodivergent treatment groups.

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ANNEXURE - I

Participant Information Sheet

Title of the study : Bite force changes during fixed orthodontic treatment in different vertical facial morphology

Pricipal Invetigator:

Name of the research institution: Tamilnadu government dental College & hospital

Purpose and procedure of the study:

- Occlusal bite force will be recorded in subject on eight separate occasions prior to treatment(T0)
- Orthodontic treatment with preadjusted edgewise orthodontic appliance 0.022 inch MBT prescription
- OBF will be recorded one week after treatment(T1) and end of every month for six months(T2-T7) Occlusal bite force recorded using the strain gauge transducer
- OBF will be bilaterally measured in the first permanent molar region. Before recording, each subject will be instructed to sit upright, looking forward without support and with the Frankfort plane parallel to the floor. The load cell unit will be placed parallel to the occlusal plane. Each subject will be instructed to bite as hard as possible on the silicone tubing fixed on the biting element, covered by a polyethylene tube (disposable cap) without moving their head.
- Three OBF measurements will be recorded on each side with a 15 second rest between each bite. The maximum OBF measurement achieved on each side will be recorded.

Risk of participation: Discomfort of orthodontic treatment

Benefits of participation : Patient gets benefit of orthodontic treatment.

1. Confidentiality:

The privacy of the patients in the research will be maintained throughout the study. In the event of any publication or presentation resulting from the research , no personally identifiable information will be shared.

2. Participant's rights:

Taking part in the study is voluntary. You are free to decide whether to participate in the study or to withdraw at any time. Your decision will not result in any loss of benefits to which you are otherwise entitled.

3. Compensation: NIL

Contacts:

For queries related to the study:

PRMARY INVESTIGATOR: DR.A.PREMA

CONTACT DETAILS: PG SECTION,DEPT OF ORTHODONTICS,
TAMILNADU GOVT DENTAL COLLEGE
& HOSPITAL,
FRAZER BRIDGE ,Chennai-600003.
PHONE NUMBER: 9884608840

For queries related to the rights as a study participant, please write to:

The Chairperson,
Tamilnadu govt dental college & hospital,
Frazer bridge ,
chennai-600003.

ANNEXURE - II

ஆராய்ச்சி பற்றிய தகவல் படிவம்

மரு.அபிரேமா ஆகிய நான் மரு.விமலா MDS., அவர்களின் வழிநடத்துதலின் கீழ் "பல் சீரமைப்பு சிகிச்சை மேற்கொள்பவர்களின் அதிகபட்ச கடிக்கும் விசையினை மதிப்பீடு செய்தல்" என்ற தலைப்பின் கீழ் ஆய்வு மேற்கொள்ள உள்ளேன்.

ஆய்வின் நோக்கம்:

முக வடிவத்தையும் தாடை எலும்புகளின் வடிவத்தையும் கொண்டு அதிகபட்ச கடிக்கும் விசையை மதிப்பீடு செய்தல்.

செய்முறை:

இந்த ஆராய்ச்சியின் போது பொதுவாக அனைவருக்கும் செய்வது போலவே பல் சீரமைப்பு சிகிச்சை மேற்கொள்ளப்படும். அதன் பின்னர் கடிக்கும் விசையை மதிப்பிடுவதற்காக ஓர் மின் சாதன கருவி கடிப்பதற்கு பயன்படுத்தப்படும். அந்த கருவியின் கடிக்கும் பகுதி இரப்பரால் மூடப்படும். அதன் மேல் கடிக்க வைத்து கடிக்கும் விசையை மருத்துவர் மதிப்பீடு செய்வார். இவ்வாறு ஒவ்வொரு மாதத்திற்கும் (ஆறு மாதம்) கடிக்கும் விசை மதிப்பீடு செய்யப்படும்.

இரகசிய தன்மை :

நோயாளிகள் பற்றிய குறிப்புகள் ஆராய்ச்சி முடியும் வரை ரகசியமாக பாதுகாக்கப்படும். இந்த ஆராய்ச்சியை வெளியிடும் போது நோயாளிகளின் தனிப்பட்ட விவரங்கள் எதுவும் பாதிக்கப்படமாட்டாது.

பங்குபெறுவோரின் உரிமை :

இந்த ஆராய்ச்சியில் பங்கு பெறுவது நோயாளிகளின் தனிப்பட்ட விருப்பம். மேலும், நோயாளிகள் இந்த ஆராய்ச்சியிலிருந்து எப்போது வேண்டுமென்றால் விலகிக் கொள்ளலாம். நோயாளிகளின் இந்த முடிவினால் அவருக்கோ அல்லது ஆராய்ச்சியாளருக்கோ எவ்வித பாதிப்பும் கிடையாது.

இந்த ஆராய்ச்சியின் முடிவுகள் நோயாளிகளுக்கு ஆராய்ச்சி முடியும் தருவாயிலோ அல்லது இடையிலோ தெரிவிக்கப்படும். ஆராய்ச்சியின் பொழுது ஏதும் பின் விளைவுகள் ஏற்பட்டால் அதை சரிசெய்ய தகுந்த உதவிகள் அல்லது தேவையான சிகிச்சைகள் உடனடியாக மேற்கொள்ளப்படும்.

இழப்பீடு : எதுவும் வழங்கப்படமாட்டாது.

ஆய்வு பற்றிய தகவலை பெற
மரு.அபிரேமா
இரண்டாம் ஆண்டு MDS,
முதுநிலை மாணவி,
தமிழ்நாடு பல் மருத்துவ கல்லூரி மற்றும் மருத்துவமனை,
சென்னை-600 003.

செல்பேசி : ____________

நோயாளியின் பெயர்	கையொப்பம் / கைரேகை தேதி
ஆராய்சியாளரின் பெயர்	கையொப்பம் / கைரேகை தேதி

ANNEXURE - III

Informed Consent Form

"Bite force changes during fixed orthodontic treatment in different vertical facial morphology".

Participant ID No:

"I have read the foregoing information sheet given to me about the methods and procedures to be followed for the study, or it has been read to me. I have had the opportunity to ask questions about it and any questions I have asked have been answered to my satisfaction. I consent voluntarily to participate as a participant in this study and understand that I have the right to withdraw from the study at any time without in any way it affecting my further medical care."

Date	Name of the participant	Signature/thumb impression of the participant

[The literate witness selected by the participant must sign the informed consent form. The witness should not have any relationship with the research team; if the participant doesn't want to disclose his / her participation details to others, in view of respecting the wishes of the participant, he / she can be allowed to waive from the witness procedure (This is applicable to literate participant ONLY). This should be documented by the study staff by getting signature from the prospective participant]

"I have witnessed the accurate reading of the consent form to the potential participant and the individual has had opportunity to ask questions. I confirm that the individual has given consent freely"

Date	Name of the witness	Signature of the witness

Date	Name of the interviewer	Signature of the interviewer

ANNEXURE - IV

சுய ஒப்புதல் படிவம்

பெயர் : ஆராய்ச்சி சேர்க்கை எண் :
வயது :
பால் :

ஆராய்ச்சி செய்யப்படும் தலைப்பு

"பல் சீரமைப்பு சிகிச்சை மேற்கொள்பவர்களின் அதிகபட்ச கடிக்கும் விசையினை மதிப்பீடு செய்தல்"

ஆராய்ச்சி நிலையம் : அரசு பல் மருத்துவக் கல்லூரி. சென்னை-600 003.

பங்கு பெறுபவரின் பிறந்த தேதி : தேதி _______ மாதம் _______ / வருடம் _______

இந்த ஆய்வு சம்பந்தமாக நான் மேலே கூறப்பட்ட தகவல் படிவத்தை முழுமையாக படித்துப் பார்த்தேன் என்று உறுதி கூறுகிறேன்.

நான் இது தொடர்பாக அனைத்து கேள்விகளுக்கும் நிறைவான பதில்கள் பெறப்பட்டேன்.

இந்த ஆய்வில் எனது பங்கு தன்னிச்சையானது என்றும் எந்த நேரத்திலும் இந்த ஆய்வில் இருந்து சட்ட உரிமைகள் பாதிக்கப்படாமல் விலகிக் கொள்ள சம்மதிக்கிறேன்.

மருத்துவ ஆய்வு அதிகாரிகள். எனது சிகிச்சை தொடர்பான பதிவேடுகளை பார்வையிடவும். எந்த நேரத்திலும். ஆய்வில் இருந்து நான் விலகினாலும் பார்வையிட சம்மதிக்கிறேன். எனது அடையாள குறிப்புகள் மூன்றாவது நபருக்கு தெரிவிக்கப்படமாட்டாது என்று புரிந்து கொண்டேன்.

இந்த ஆய்வு அறிக்கைகளை பயன்படுத்தவும். வெளியிடவும் நான் சம்மதிக்கிறேன். ஆய்வாளர் எனது மருத்துவ குறிப்புகளை வெளியிட தடையாக இருக்கமாட்டேன் என உண்மையாக சம்மதிக்கிறேன்.

பங்கேற்பவரின் கையொப்பம் : ________________ இடம் ____________ தேதி

கட்டை விரல் ரேகை

பங்கேற்பவர் பெயர் மற்றும் விலாசம்

ஆய்வாளரின் பெயர் :
ஆய்வாளரின் கையொப்பம் :

ANNEXURE – V

TAMIL NADU GOVERNMENT DENTAL COLLEGE & HOSPITAL, CHENNAI – 3.

TELEPHONE : 044-253403343
FAX: 044- 25300681

Ref No: R. C. NO: 0420/DE/2016
date : 01-08-2016

Sub: IEC review of the research proposals,

Title of the work: Bite Force changes during fixed orthodontic treatment in different vertical facial morphology

Principal Investigator: Dr. A.Prema
III year MDS

Department : Department of Orthodontics and dentofacial orthopeadics
Tamil Nadu Govt. Dental College & Hospital , Chennai-3

Thank you for submitting your research proposal , which was considered at the Institutional Ethics Committee meeting held on the 01.07. 2016, at TN Govt. Dental College and the documents related to the study referred above were discussed and the modifications done as suggested and reported to us through your letter dated 19-04-2016 have been reviewed.

The decision of the members of the committee , the secretary and the Chairperson IEC of TN Govt. Dental College is here under:

Approved	Approved and advised to proceed with the study
Approved with suggestions	---------------------------------------
Revision	---

The principal investigators and their team are advised to adhere to the guide lines given below:

1. You should get detailed informed consent from the patients / participants and maintain confidentiality.
2. You should carry out the work without affecting regular work and without extra expenditure to the Institution or the Government.
3. You should inform the IEC, in case of any change of study procedure, site, and investigating guide.
4. You should not deviate from the area of work for which you have applied for ethical clearance.
5. You should inform the IEC immediately in case of any adverse events or serious adverse reactions. You should abide to the rules and regulations of the institution(s) .
6. You should complete the work within specific period and if any extension of time is required, you should apply for permission again to do the work.
7. You should submit the summary of the work to the ethical committee every 3 months and on completion of the work.
8. You should not claim any kind of funds from the institution for doing the work or on completion/ or for any kind of compensations.
9. The members of the IEC have the right to monitor the work without prior intimation.
10. Your work should be carried out under the direct supervision of the guide/ Professor.
11. The investigator and Guide should each declare that no plagiarism is involved, in this whole study and enclose the undertaking in dissertation/ thesis.

MEMBER SECRETARY,
INSTITUTIONAL ETHICS COMMITTEE
Tamil Nadu Govt. Dental College & Hospital
Chennai

CHAIR PERSON
INSTITUTIONAL ETHICS COMMITTEE
Tamil Nadu Govt. Dental College & Hospital
Chennai